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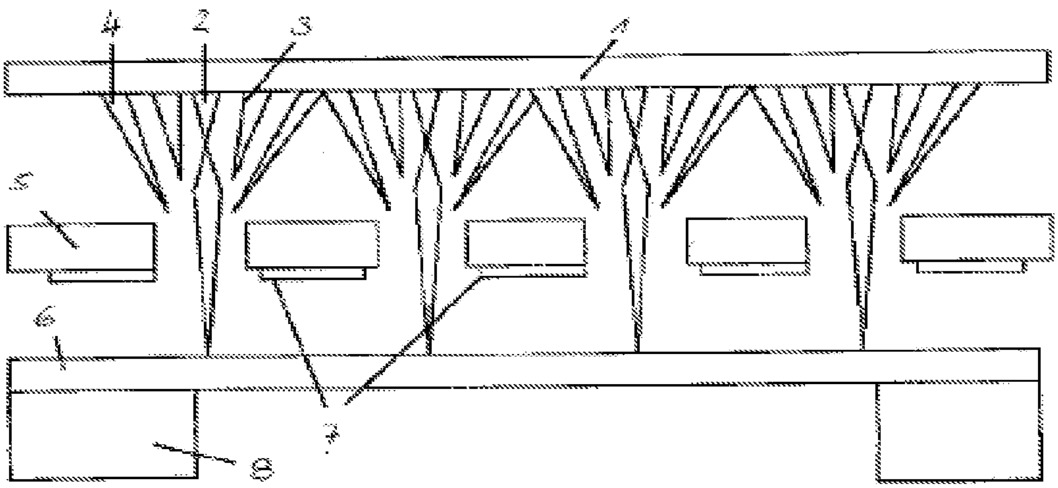
Method and means to produce picture element radiation sources for flat panel screens

Main Claim:
Method to produce picture element radiation sources for flat panel screens using focused multiple radiation systems and additive corpuscular radiation lithography on an insulating substrate, characterized in the way that at first on a vacuum tight insulating ground plate a metallized pattern for conducting potentials is structured and produced using known lithographic methods (optical, X-Ray, or corpuscular radiation), and secondly after this step for the fabrication of a production machine and also for the production of the end product generally inclined deposits are produced using multiple corpuscular –beam- induced deposition lithography and on a second substrate emitter wires are built onto the conducting structure by guiding the corpuscular beam accordingly or tilting the substrate , and also current limiting wires are deposited on the second substrates structure, and on a third raster extractor wires having opposite inclination or are axially misplaced to the emitter wires are generated



Description

0001: The invention relates to a method of producing picture element radiation sources for flat panel screens according to the principal claim of claim 1 given way and on a device to produce the picture element radiation sources for flat panel screens according to the way given in the principal claim of claim 7.

State of the Art

0002: Such a method is for example taught in H.F. Gray “ The field emitter display”, Information Display Vol. 9, Nr. 3 (1993) p.9-14.

0003: Up to now flat panel colour displays are produced using known techniques and silicon or molybdenum emitters as radiation sources produced in lithographic techniques with light- or electron beam lithography in combination with vacuum deposition techniques and conventional wet or dry etching techniques. They require due to the fragility of the radiation sources a sufficiently stiff and hence heavy glass screen substrate, and , due to the low

emittance of the cathodes > 10 µA at 50 V relatively high voltages for their application. To have battery operation, voltage transformers are needed.

0004: Due to the aerial structure of the extractor electrode, which is required to have redundancy using a large number of cathodes – e.g. 9 to 16 per picture element- a large capacitance of each pixel is to be charged.

0005: Up to now the experiments to improve the performance of the flat panel screen as a product failed mainly due to the weakness of the picture element radiation sources.

0006: From the patent US 4,618,801 a method is known for a vacuum-technologic display using thermionic emitters a, extractor grid, beam forming optics phosphor screen and vacuum encapsulation using glass. This principle of small display is successfully employed, however it is due to the thermionic emitters and the therefore needed high amount of energy not economically applicable in large area displays like flat panel displays.

0007: the US patent 4,969,850 teaches a method to produce a cold cathode field emission device. In this method rod shaped electron emitters are obtained using etched cylindrical holes in alumina and filling them with metal, and using the alumina tube matrix as an in parts lost form by chemically etching the alumina to release in part or totally the metal wires of the filling. Since the surface tension of the final wet chemical treatment bends the metal wires which results in alternating bent together metal rods, which can be used as field emitters. An extractor structure is not provided. This method does not lead to economic production and not to steady and reproducible produced field emitter electron sources.

0008 US 5,259,799 teaches a method which uses silicon field emitter tips, which are sharpened by additional oxidation and by using several lithographic and semiconductor technology methods to render an emitter. In addition the method uses a self aligning method for generating multi-structural electrodes in an insulating layer on a chip with silicon technology including a micromechanical polishing step to open the structures. The goal is , to produce an corpuscular beam, which is controlled by electron sources produced with silicon technology as it is used in silicon chip fabrication. The company Micron successfully developed a brilliant screen finder display for a digital camera.

The Task

0009: The invention shall solve the task to render an improvement in the production means for the picture element corpuscular radiation sources, as well as an improvement applicable in the method and in the device to produce the production system and also the product .

0010: The invention solves this task by the steps of methodology as given in claim 1. Advantageous possibilities of further developments of the method are given in the claims 2 to 6.

0011: A device for the production of the production machine and of the flat panel screen itself is described in claim 7.

0012: A favourable further development of such a device is given in the claims 8 to 13.

0013: The principle of the invention is the parallel production of the picture elements of the flat panel screen using the corpuscular beam induced deposition technique.

0014: The main difference to other earlier attempts to build the flat panel screen with field emitter radiation sources using silicon technology on a silicon basis is given in this method by using multiple electron beam systems, which use themselves metallic wire tips as field emitters. Such emitters are obtained having extraordinary characteristics with respect to material composition, here gold-carbon compound materials, which are generated under high electronic excitation using a beam power density of > 60 $MW/cm,^2$ in electron beam scanning electron microscopes using field emission cathodes.

0015: Gold has been reported as the most stable emitter rendering so far the highest emission current. The emitter wires, which are produced by deposition with electros can be fabricated having an arbitrary inclination with respect to the substrate normal by beam control or substrate tilt, and can sustain 0.5 MA/cm^2 before melting. The field emission current of one emitter is there 120 μA at 18 V and starts at 12 V. The preferred emitter – extractor distance was 500 nm. Using the accelerating lens the single beams are accelerated to the energy sufficient for the Deposition.

0016: Since electron beam induced deposition can also be employed on glass or plastic materials carrying conducting voltage feed lines it is possible to construct flat panel displays on a flexible substrate including control electronics in a hybrid fashion. The fragility of conventional screens is avoided by using flexible base materials. In addition simultaneously the weight of the system is reduced. By using multiple beam sources and beam guiding systems the production method is similar to a printing technique but using a flat system.

0017: As can be seen from high resolution Transmission microscope images the deposited tips are free from a contamination coating and is built from gold single crystals, having only a few lattice planes and therefore are subject to internal strain, which reduces the lattice constant of the single crystals. The single crystals have a diameter ranging from 3 to 8 nm and therefore represent areas of increased field strength, which explains the low onset voltage for field emission.

0018: Since electron beam induced deposition can also be employed on glass or plastic materials carrying conducting voltage feed lines it is possible to construct flat panel displays on a flexible substrate including control electronics in a hybrid fashion. Using a honeycomb supporting structure and the moderate vacuum requirements the display can be kept very flat and thin, it is even possible to fabricate it foldable or rollable. This offers a variety of applications in image processing. The device can be battery powered using conventional 9 V batteries due to a low onset voltage of the emission and due to a low accelerating voltage to generate visible light in the phosphor of the screen. The required power is for 1 μA emission per emitter and 20 V total accelerating voltage for 3 colours and 106 picture elements in 100 cm^2 : 2 Watt per cm^2. With 1/20 sec as a pixel-light emission time the total required energy is 0.1 Wsec/ cm^2

0019: Using wires for the picture element generator the capacity to be charged is reduced by a factor of 160, referred to the voltage feed lines capacity, which in turn leads to a reduced requirement for the total charging power for the image control process.

0020: Brodie taught a multi-beam system using a single electron source as a conventional lithography system, see Ivor Brodie, Eugene R. Westerberg, Donald R. Conde, Julius J. Muray, Norman Williams, Leonard Gasiorek, " A multiple Electron Beam Exposure System for high Throughput, Direct Write Submicrometre Lithography", IEEE Transactions on

Electron Devices, Vol. 28, No 11, November 1981, S. 1422ff. Chang and Kern describes multiple beam systems using a SAFE technique for the application in electron beam lithography, however their system is to complicated to be realized in the near future, see L.P. Muray, U. Staufer, E. Bassous, D.P. Kern,T.H.P. Chang "Experimental evaluation of a scanning tunnelling microscope-microlens system" , J. Sci. Vac. Technol. B 9(6), Nov/ Dec 1991, S 2955 ff. The in this paper suggested application of macroscopic lenses doe not allow to focus the beam to a few nm diameter due to the large lens aberrations.

Example

0021: The invention is in the following describes by examples of realisation. The according drawings show:

0022: Fig 1 schematic of the device used for building the flat screen,

0023: Fig 2a: one emitter and two extractor electrodes,

0024: Fig. 2b: one emitter and three extractor electrodes,

0025: Fig 2c: on emitter and four extractor electrodes,

0026 Fig 3a shows on picture element, composed from one emitter and two extractors- and two focusing electrodes,

0027 Fig. 3b: one picture element. Composed from Emitter with three extractor and three focusing electrodes

0028: Fig. 3c shows one emitter with four extractor electrodes and four focussing electrodes and

0029: Fig. 4 gives a schematic representation of the setup of the flat panel screen with a focusing means and an ion mirror, composed from Emitter, extractor lens, Focusing lens, Accelerating area, Accelerating lens and screen.

0030: Fig. 1 shows schematically the setup of the production system for the parallel deposition of the picture elements of the flat panel screen using electron or ion beam induced deposition.

0031: The production method for the flat panel screen does not use silicon or other semiconductor materials, but is performed using additive electron or Ion beam lithography and uses corpuscular beam induced deposition.

0032: For this purpose , as Fig. 1 shows, on an insulating possibly also flexible base material 1 , which insulates also vacuum, a single layer or multiple layer of voltage feed lines made by metallization of a structured layer by lift off, or made from other conducting layer is produced using lithography with light, x-rays or corpuscular beams. The produced conducting lines serve the purpose to feed potentials to the emitter wires 2 , to the emitter tip having negative potential relative to the extractor wire 3 having itself a positive potential. The emission current is possibly automatically stabilized by proper means for each tip.

0033: The extractor wires 3 are surrounded by focusing and deflection wires 4, which help to influence the pixels in parallel. The accelerating electrode 5 carries also detectors 7 to detect secondary radiation (Ions, Electrons, X-Rays) , which help to control the focusing of the beams in single or parallel manner.

0034: The target of the screen 6 is hold to the deposition enabling potential (5-10 kV) It is moved under piezo-electrical control with high precision and by mechanical movement with a resolution of 0.1 µm, and in doing this the single pixel elements consisting from Extractor and emitter and the accordingly larger fields of the Pixels can be recorded.

0035: The space between Target 6 and middle electrode 5 is filled with an organometallic precursor of sufficient vapour pressure, which on the one hand does not disturb the travel of the focused electron beam, and on the other hand delivers sufficiently enough material to construct the emitter 2 and extractor – needle 3, which compose the picture elements, and this construction takes place on the target structurized with voltage feed lines in a speed which allows an area production of sufficiently high speed. In working in parallel on several pixels it is possible to produce such screens in large areas.

0036: The whole arrangement can produce in several production steps a quadratic emitter-extractor field of 10 cm side length having colour pixel sizes of 0.1 mm diameter and 1000 x 1000 pixels. Since one colour pixel consists from three emitter- collector wire pairs, with distances of 1 µm in each pair, and since the pairs are positioned in an distance of 1/3 picture element = 33 µm therefore it is sufficient space between the pixels for further redundant emitters which also illuminate the pixels as well as for the conducting lines for the screen.

0037: To produce the flat screen it is possible to use a similar production system generating a 2 layer structure which make the 3 r-G-B extractor lines and perpendicular to those 3 R-G-B-Emitter lines . The image is generated in the flat screen in a conventional way by multiplexing the emitter and extractor potentials via the according lines with a frequency of 50 Hz per picture. The required wiring of the conducting lines is done in conventional Hybrid Technology e.g. using flip chip soldering methods.

0038: The conducting lines serve to feed the potentials to supply the emitter wire and the emitter tip with negative potential in sufficient amplitude. The wire carrying the emitter tip can be fabricated from materials of different resistance which allows to heat the emitter tip by Joules heating of the wire and serves to generate constant emission characteristics, second: it serves to desorbe adsorbed gases from the tip, and third: to limit the emission current by a voltage drop in the resistive material to protect the tip against burn out by an exponentially rising current from the tip.

0039: Such at each emitter located individual protective resistor and current limiting resistor can also be separately built in to the line supplying the emitter and can be produced when building the wire. The emitter tip itself can be built using changed deposition conditions a metallic emitter with a low resistivity and lower carbon content. Emitter wire and tip wire are either parallel or inclined with respect to the extractor wire or to two extractor wires. Also other geometries of the emitter extractor ensemble are suggested, having three, four or even six or eight wires, which have additional controlling functions for the emitted beam.

0040: The sandwich structure of the screen can be very thin, which results in the requirement of having just fine vacuum is sufficient for the short path length of the electrons. A positive electrode assembled before the screen, which is as an honeycomb structure assembled in short

distance to the screen, serves as an ion mirror and prevents that ions generated by primary and secondary electrons generated at the phosphor reach the tips and destroy those.

0042: having 1000 picture elements a 10 cm by 10 cm screen for a colour picture can be generated. Since each colour picture element consists from three emitter collector wire pairs, which stand in a distance < 1 µm and the pixels have 33 mm distance, there is enough space in the intermediate space between the pixels for conducting lines.

0043: A 2 layer connecting lines structure is employed to generate the three negative R-G-B-Lines and the according R-G-B Extractor lines perpendicular to the others. The image is produced by< conventional multiplexing with 1/ 50 sec per image. The required control circuitry for the connecting lines are produced in conventional hybrid technology , e.g. using Flip.-Chip solder technology.

0044: From the figures Fig 2a, 2b,2c, as well 3a,3b and fig 3c differing production forms of the picture generating structures consisting from voltage feed lines, emitter, Extractor in varying number are shown. The figures each show:

0045: Fig 2a shows an emitter with 2 extractor electrodes. Those are inclined to define the accelerating field, which accelerates the electrons to the screen.

0046 Fig. 2b shows an emitter surrounded by 3 extractor electrodes. Those are inclined to render the accelerating field, which brings the electrons to the screen.

0047: Fig 2c. shows an emitter surrounded by four extractors. Those are inclined to render the accelerating field, which brings the electrons to the screen.

0048: According t figure 2a, 2b, 2c the emitter required per pixel is surrounded by 2, 3 or 4 extractor electrodes in the form of wires with tips, which are produced by electron beam induced deposition directly on the connector lines, or they are built using the lithographic process to convert palladium acetate or an other organometallic substance , via electron beam radiation in to an metallic deposit of sufficient conductivity.

0049: Fig 3 a shows an emitter surrounded by 2 extractor and 2 focusing electrodes. Those are inclined to render the required accelerating field which send the electrons to the screen. The focusing electrodes allow to shape the form and focus in the picture element with a cylinder lens action which allows an astigmatic focus of the pixel in direction.

0050 Fig 3 b shows and emitter surrounded by 3 extractor electrodes and three focusing electrodes. Those are inclined to render the required accelerating field which send the electrons to the screen, ad to limit the dimension of the pixel at the screen. The required ground electrode is not realizes, but can be replaced by the screen electrode.

0051 Fig 3 c shows an emitter surrounded by 4 extractor electrodes and four focusing electrodes. Those are inclined to render the required accelerating field which send the electrons to the screen. The focusing electrodes allow to shape the form and focus in the picture element with 2 different magnifications in x and y.

0052: According to the figures 3a, 3b, 3 c there exist aside of the extractor electrodes additional focusing electrodes. Those affect the electrons emitted from the emitter by adding a retarding or accelerating field.

0053: In case that he extractor wires from Fig.2a, Fig 2b, Fig 2c, Fig 3a, Fig 3b, and Fig 3care used as emitters, which surround an central extractor and are surrounded by the focussing wires, which in this case act as further extractor the operation of the structure as high current emitter structures with many parallel emitting cathodes per pixel are possible.

0054: Fig. 4 shows the schematic of the flat panel screen built from picture element sources and with a switched acceleration aperture raster plate and from the screen.

0055:Fig. 4 shows, that an aperture raster plate which serves as an accelerating electrode is positioned subsequent to the picture element structures. This accelerating structure is supplied with a further positive accelerating potential and focuses and the bundle further. This aperture plate can also be used as an ion mirror, to repel the ions released from the screen and to prevent their impact to the cathode. Further on this aperture raster plate can be used as a stencil to evaporate the phosphors 11 in the pattern of the picture elements.

0056: The emitter tip carrying wire 2 (see Fig. 1) can be fabricated from materials having different resistivity, which allows to heat the emitter tip by Joule's heating to assure constant emission properties, secondly to release adsorbed gases from the tip, and third: to limit the emitted current by a voltage drop generated in the emitter resistor which prevents the destruction of the tip by exponentially rising currents in case of high voltage peaks, which would destroy the tip.

0057 In a further form the individual protection and maximum current limiting resistor is separately built near the emitter , or when building the emitter is incorporated in the emitter wire. The emitter wire is then produced under changed deposition conditions as an more metallic conductor with a lower resistivity and lower carbon content. Emitter wire and tip are oblique with respect to the extractor wire 3, or to two extractor wires.

0058: By the insulating, large area and special honey comb structure 9 the screen plate 10 is carried which is coated with phosphors 11 in the areas according toe structure of the picture elements.

0059: The screen phosphor pattern is fabricated in a way, that the electrons emitted from the emitter excite the phosphors to emit light in the wanted colour and intensity. In between the emitter – extractor plate 1 and the phosphor screen plate 10 , which possibly is fabricated from flexible vacuum insulating material having a transparent conducting layer deposited, the accelerating voltage is applied.

0060: The sandwich structure of the screen can be very thin, which results in the requirement of only roughing pump vacuum , since the electron beam path is short. A positive electrode in front of the phosphor screen 12, which can be integrated as a continuous layer into the insulating honeycomb structure 9, is supplied with positive potential Us , positive with respect to the conducting underlying layer under the phosphor materials layer and serves as an ion mirror and prevents, that ions generated by the primary and secondary electrons at the phosphor material are accelerated back to the tip of the cathode 3 and destroy this, see also Fig. 4.

Claims

1. Method to produce the picture elements sources for flast panel screen using focused multiple radiation systems and additive corpuscular deposition lithography on top of an insulating base material, characterized in a way thatat first on top of a vacuum tight , insulating base material a first pattern of voltage and current conducting lines is generated using known lithographic methods (light, X-Ray or corpuscular beam lithography), secondly in a second raster emitter wires having incorporated current limiting resistors and metallic emitter tips are produced , and in a third pattern extractor wires are deposited having opposite inclination to the normal or are axially misplaced to the emitter as extractor wires.

2. Procedure to fabricate the picture radiation sources according claim 1 characterized in a way that in a first structure pattern a two layer conducting line pattern is produced, which is supplied with a negative potential for the 3 lines each of R-G-B emitters and as a second pattern supplied with positive potential for the extractors.

3. Procedure to fabricate the picture radiation sources according claim 1 characterized in a way that the emitter wire I fabricated from materials having a different resistivity, with the emitter tip being produced in changed deposition conditions having more metallic character and a lower resistivity, and the other part being heated by Joule's heat until a constant emission characteristics is obtained, which desorbs adsorbed gases from ten tip, and limits the emission current by a voltage drop in eth emitter wire resistor to protect the tip against destruction in case of accidental over-voltage .

4. Procedure to fabricate the picture radiation sources for flat panel screens according claim 1 characterized in a way that structure normally fabricated by electron beam induced deposition alternatively lithography procedures are employed which convert Palladium acetate or other organometallic precursors by electron beam bombardment of an prefabricated layer or adsorbed layer render an metallic deposit of sufficient high conductivity.

5. Procedure to fabricate the picture radiation sources according claim 1 characterized in a way that the molecules needed for additive lithography are injected into the process and that using focused rays the wires for the emitter extractor focusing assembly are fabricated in a stepwise but also parallel manner.

6. Procedure to fabricate the picture radiation sources according claim 4 and 5 characterized in a way that the whole target is moved in a coarse and fine manner mechanically and using piezoelectric means to position the target points of the beams with coarse and fine resolution and that by the extractor and focusing electrode wires an individual fine positioning of the single beams is obtained.

7. Procedure to fabricate the picture radiation sources for flat colour screens having an emitter carrier with emitter wires, having their tips directed to the screen target and with beam collimating elements characterized in a way that for the product as for the production machine at the side of emitter wires at least one extractor wire is positioned on the emitter carrier being inclined to the emitter tip , and that for the production machine further focusing electrodes are positioned in a larger distance from the emitter, but are also inclined to the emitter wire.

8. Production machine according to claim 7 characterized in a way that the second 2 pattern is split in two separated voltage feed lines, onto which emitter wires are deposited which touch at the tip and form a hairpin, carrying a tip, and the potential connection between the separated voltage lines is given by the contact of the emitter tips, which at least in the beginning is heated to form the emitter tip via current flow and heat generation.

9. Production machine according to claim 7, characterized in a way that the one or the many electron emitters required for a picture element are each surrounded from at least two extractor electrodes in the form of wires with tips but inclined to the emitter, and are placed directly to the conducting lines of the third pattern.

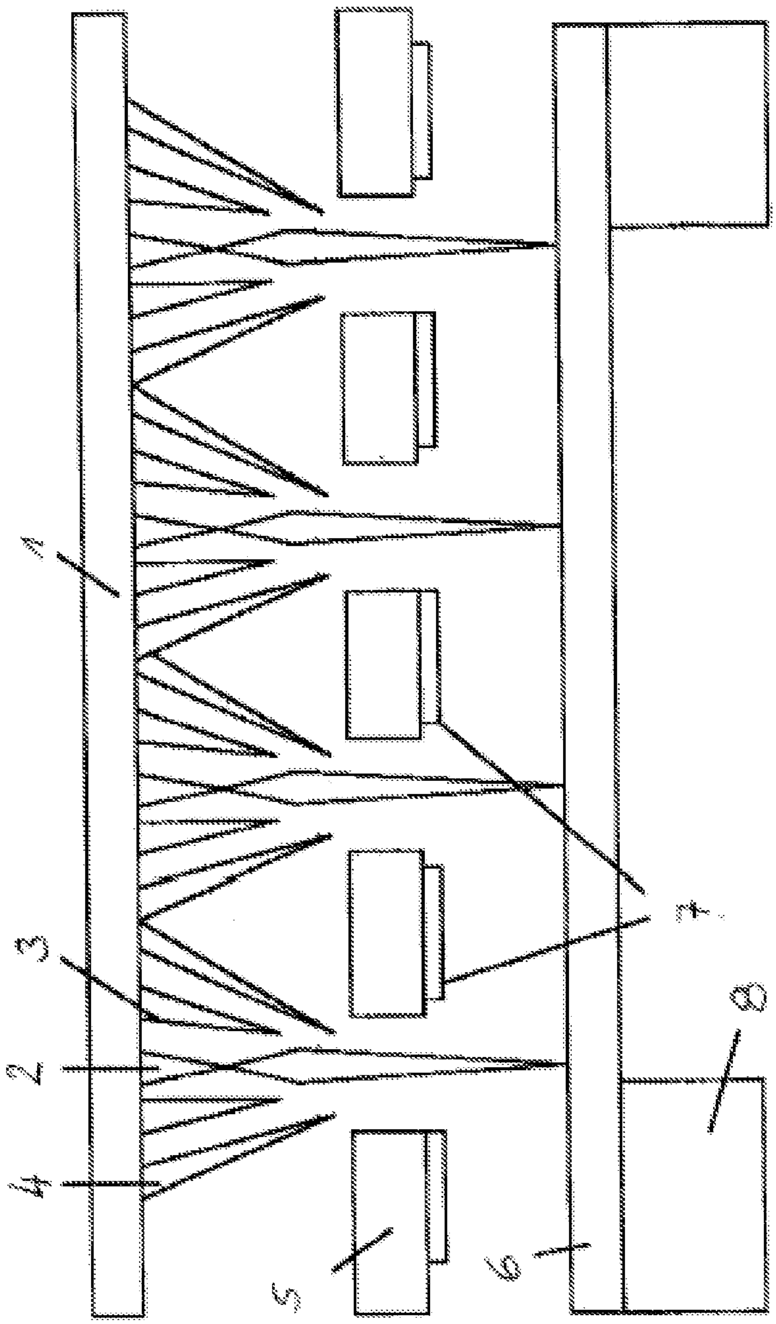
10. Production machine according to claim 7 to 9, characterized in a way that the extractor electrodes are surrounded by additional focusing electrodes of at least the same number, which act in form of an accelerating or decelerating field on to the electrons emitted from the emitter by the electric fields generated, and with this means influence and control by acting on the ray path the form of the pixel and its illumination current density distribution.

11. in between the picture element generating structures and the phosphor screen an additional accelerating electrode is incorporated acting as an ion mirror electrode, being supplied with another accelerating positive potential and acting as further focusing and collimating means on the electrons and repels ions which are generated at the phosphor from the cathode.

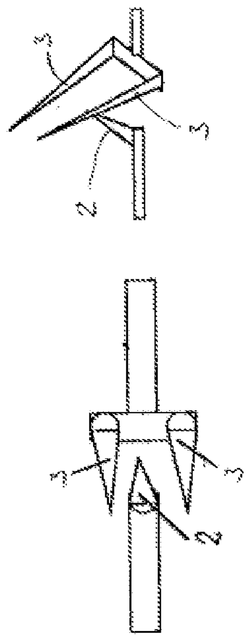
12. Production machine according to claim 11, characterized in a way that the ion mirror electrode used to generate a dynamic, the field emission not disturbing ion current is formed and arranged in an a distance defining structure between the emitter plane and the screen in a way, that the ions are deflected by non rotationally symmetric fields to a space outside from the emitter structures which generate the picture elements and its electrodes.

13. Production machine according to claim 11 and 12, characterized in a way that in between the emitter extractor structure and the ion mirror electrode a n aperture plate is inserted having to a point focusing characteristics, which is active for a field of a large number of beams.

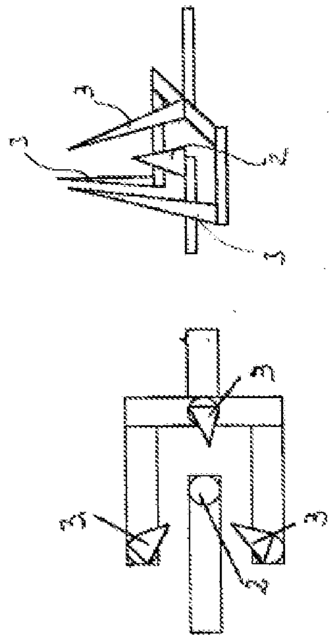
6 pages of drawing s follow.



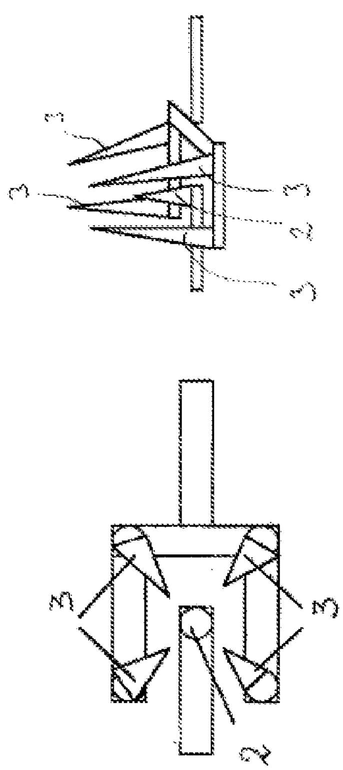
Figur 1



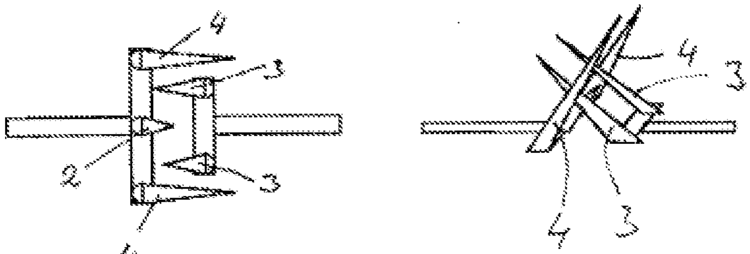
Figur 2a



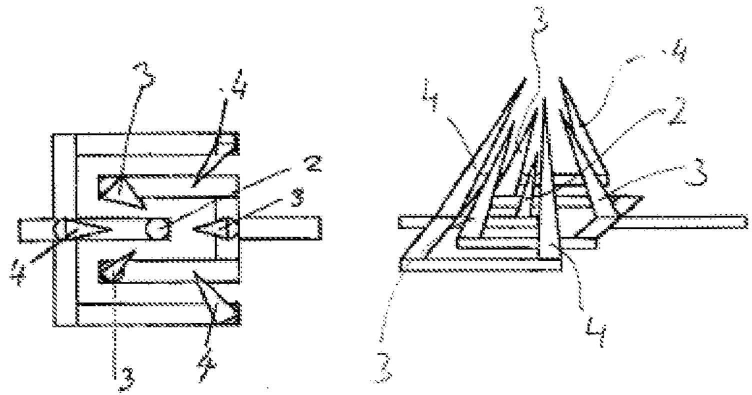
Figur 2b



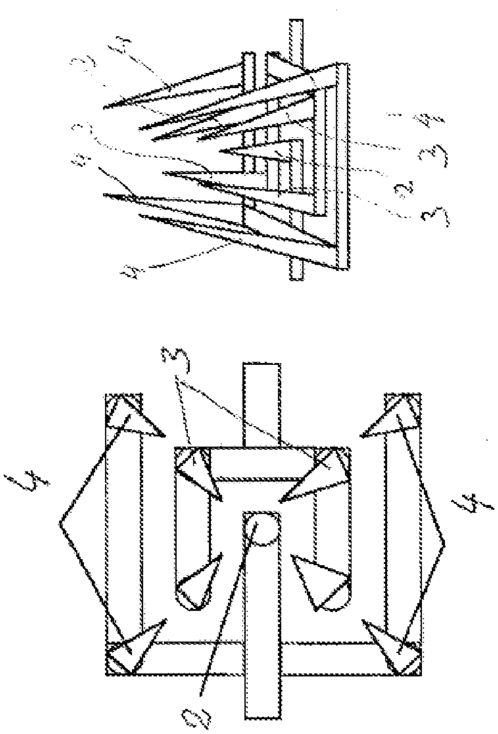
Figur 2c



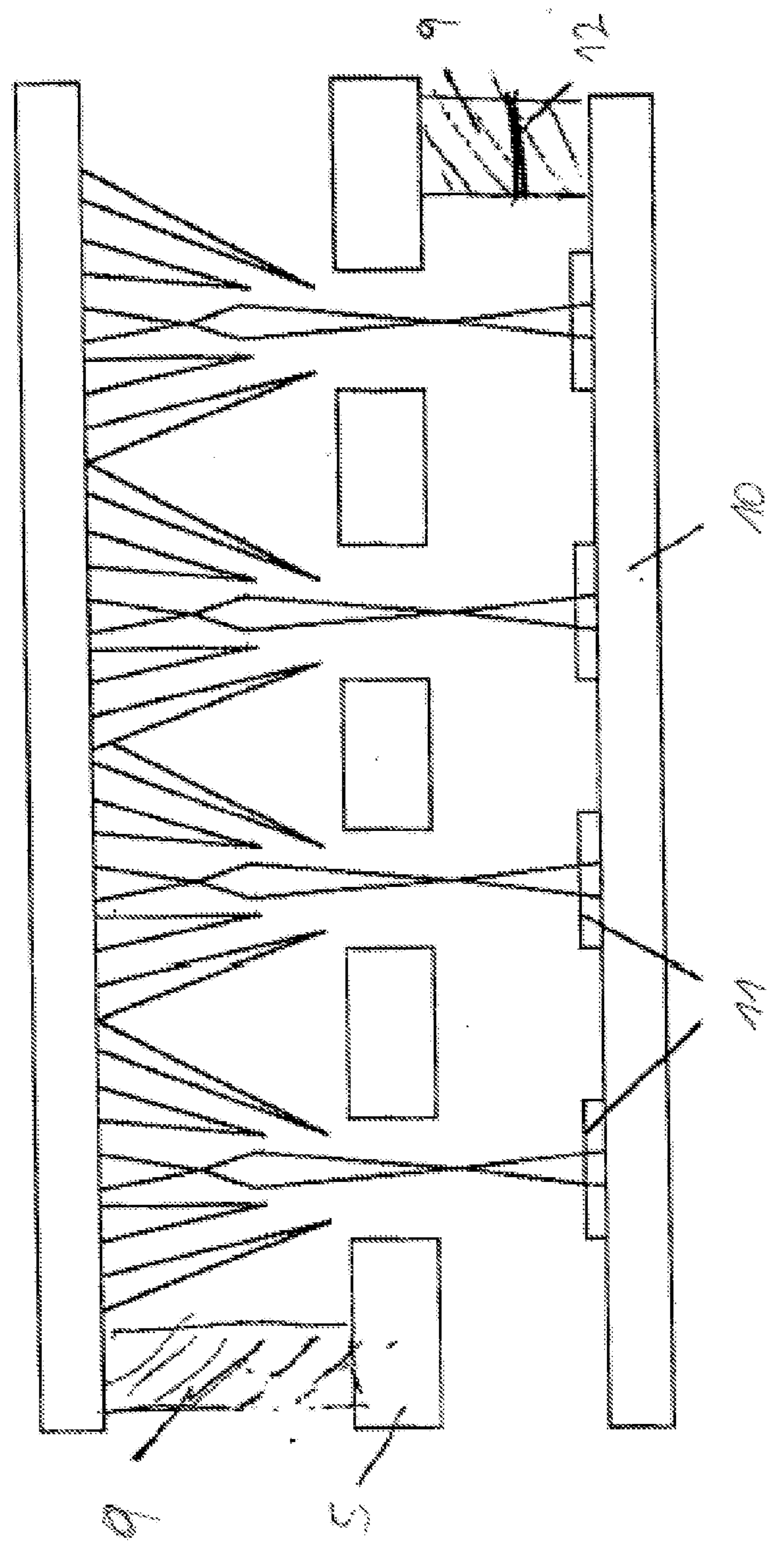
Figur 3a



Figur 3b



Figur 3c



Figur 4